CLAIMS

I/We claim:

[c1] 1. An apparatus for processing microelectronic workpieces, comprising:

a plurality of processing stations, all of the processing stations of the apparatus being manually accessible to a user to manually load microelectronic workpieces for processing, at least one of the processing stations including an application station configured to apply a material to the microelectronic workpiece;

an input/output station configured to support at least one microelectronic workpiece for automatic transfer to and from the processing stations; and

a transfer device positioned proximate to the input/output station and the processing stations, the transfer device being automatically movable to transfer microelectronic workpieces between the input/output station and the processing stations.

[c2] 2. The apparatus of claim 1 wherein the application station includes:

a first vessel configured to provide a processing fluid, the first vessel having a weir to define a level of the processing fluid;

a second vessel disposed around the first vessel to receive the processing fluid proceeding over the weir;

a workpiece support positioned to carry the microelectronic workpiece in contact with the processing fluid in the first vessel;

a first electrode support positioned in the first vessel and configured to carry a first electrode; and

a second electrode support carried by the workpiece support and positioned to carry a second electrode in contact with the

microelectronic workpiece when the workpiece support carries the microelectronic workpiece.

[c3] 3. The apparatus of claim 1 wherein the application station includes:

at least one vessel configured to provide a processing fluid;

one or more electrode supports positioned in the vessel and configured individually or together to carry a plurality of first electrodes; and

a workpiece support positioned at least proximate to the at least one vessel to carry the microelectronic workpiece in contact with the processing fluid in the vessel, the workpiece support being configured to carry at least one second electrode in contact with the microelectronic workpiece when the workpiece support carries the microelectronic workpiece.

[c4] 4. The apparatus of claim 1 wherein the application station includes:

at least one vessel configured to carry a processing fluid;

one or more electrode supports positioned in the vessel and configured individually or together to carry a plurality of first electrodes, the first electrodes being spaced annularly apart from each other; and

a workpiece support positioned at least proximate to the at least one vessel to carry the microelectronic workpiece in contact with the processing fluid in the vessel, the workpiece support being configured to carry at least one second electrode in contact with the microelectronic workpiece when the workpiece support carries the microelectronic workpiece.

[c5] 5. The apparatus of claim 1 wherein the application station includes:

a reaction vessel comprising -

an outer container having an outer wall;

a first inlet configured to introduce a primary flow into the outer container;

at least one second inlet configured to introduce a secondary flow into the outer container separate from the primary flow;

a dielectric field shaping unit in the outer container coupled to the second inlet to receive the secondary flow, the field shaping unit being configured to contain the secondary flow separate from the primary flow through at least a portion of the outer container, and the field shaping unit having at least one electrode compartment through which the secondary flow can pass while the secondary flow is separate from the primary flow, the electrode compartment being configured to receive at least one electrode.

[c6] 6. The apparatus of claim 1 wherein the application station includes:

a first vessel configured to provide an electroless processing fluid, the first vessel having a weir positioned to define a level of the processing fluid;

a second vessel disposed around the first vessel to receive the electroless processing fluid proceeding over the weir;

a support positioned to carry the microelectronic workpiece in contact with the electroless processing fluid in the first vessel; and

a reservoir configured to carry the electroless processing fluid, the reservoir being in fluid communication with the first vessel.

[c7] 7. The apparatus of claim 1 wherein at least one of the processing stations includes a metrology station having:

a support configured to releasably carry the microelectronic workpiece;

a measurement device positioned at least proximate to the support and configured to detect a characteristic of a conductive material of the microelectronic workpiece; and

an output device operatively coupled to the measurement device to transmit an output signal corresponding to the detected

characteristic of the conductive material of the microelectronic workpiece.

[c8] 8. The apparatus of claim 1 wherein at least one of the processing stations includes a spray station having:

a vessel configured to carry a fluid;

a support positioned proximate to the vessel, the support being configured to carry the microelectronic workpiece; and

a fluid manifold positioned within the vessel, the fluid manifold being coupleable to a source of fluid, the fluid manifold having a plurality of fluid jets directed toward the support to spray the microelectronic workpiece with the fluid.

[c9] 9. The apparatus of claim 1 wherein at least one of the processing stations includes a material removal station, the material removal station including a rotor having a first portion and a second portion facing toward the first portion, the first and second portions defining a chamber volume configured to removably receive the microelectronic workpiece, wherein the first portion includes a first fluid passage having a first aperture directed into the chamber volume and facing the second portion, the first aperture being coupleable to a first fluid source, and wherein the second portion includes a second fluid passage having a second aperture directed into the chamber volume and facing the first portion, the second aperture being coupleable to a second fluid source.

[c10] 10. The apparatus of claim 1 wherein at least one of the processing stations includes a thermal processing station having a heater configured to elevate a temperature of the microelectronic workpiece.

[c11] 11. The apparatus of claim 1 wherein at least one of the processing stations includes a thermal processing station, the thermal processing station having:

a base;

a support carried by the base and configured to removably contact the microelectronic workpiece;

a lid proximate to the base, at least one of the base and the lid being movable relative to the other between a closed position and an open position, the lid and the base defining a thermal processing space when in the closed position;

a heater positioned between the base and the lid;

a first heat sink positioned proximate to the heater and movable relative to the heater between a first position with the first heat sink in thermal contact with the heater and a second position with the first heat sink spaced apart from the heater; and

a second heat sink positioned proximate to the first heat sink, the second heat sink being in thermal contact with the first heat sink when the first heat sink is in the second position.

[c12] 12. The apparatus of claim 1, further comprising a shield positioned at least proximate to the transfer device to at least restrict access by the user to the transfer device.

[c13] 13. The apparatus of claim 1 wherein the processing stations are arranged along a generally straight first line and wherein the transfer device includes a robot configured to move along a second generally parallel first line, and wherein the apparatus further comprises an enclosure disposed around at least one of the processing stations, the enclosure having a first access aperture through which the user can manually access all the processing stations, the enclosure having a second access aperture accessible to the robot and through

which the robot can move microelectronic workpieces, with the second line being positioned between the first line and the first and second access apertures.

[c14] 14. The apparatus of claim 1 wherein all the processing stations of the apparatus are manually accessible from a single side of the apparatus.

[c15] 15. The apparatus of claim 1 wherein the application station includes a vessel and a support movably positioned proximate to the vessel and configured to carry the microelectronic workpiece, the support being moveable between a first transferring position and a second transferring position spaced apart from the first transferring position, wherein the support is oriented to receive the microelectronic workpiece from the transfer device when the support is in the first transferring position, and wherein the support is oriented to receive the microelectronic workpiece manually from the user when the support is in the second transferring position, the support being configured to selectively stop its motion at the first and second transferring positions.

[c16] 16. The apparatus of claim 1, further comprising an enclosure having a first surface with a first access aperture and a second surface facing opposite from the first surface and having a second access aperture, the first and second access apertures alone being sized and positioned to allow manual access to the transfer device and all the processing stations for loading the microelectronic workpieces and/or servicing an interior region of the enclosure.

[c17] 17. The apparatus of claim 1, further comprising an enclosure disposed around at least one of the processing stations, the enclosure having a first surface facing a first direction and a second surface facing opposite the first surface, the first surface having at least one first access aperture, the second surface having at least one second access aperture, and wherein the enclosure has a third and a fourth surface extending between the first and second surfaces and facing in

opposite directions from each other, and wherein the third and fourth surfaces have no apertures sized to allow manual access to the transfer device or the processing stations.

[c18] 18. The apparatus of claim 1 wherein the application station includes:

at least one vessel configured to carry a processing fluid;

one or more electrode supports positioned in the vessel and configured individually or together to carry a plurality of first electrodes, the first electrodes being spaced annularly apart from each other; and

a workpiece support positioned at least proximate to the at least one vessel to carry the microelectronic workpiece in contact with the processing fluid in the vessel, the workpiece support being configured to carry at least one second electrode in contact with the microelectronic workpiece when the workpiece support carries the microelectronic workpiece, and wherein the apparatus further comprises a spray station having:

a spray vessel configured to provide a spray fluid;

a spray support positioned proximate to the spray vessel and configured to carry the microelectronic workpiece; and

a spray fluid manifold positioned within the spray vessel, the spray fluid manifold being coupleable to a source of spray fluid, the spray fluid manifold having a plurality of fluid jets directed toward the support to spray the microelectronic workpiece with the spray fluid.

[c19] 19. The apparatus of claim 1 wherein the application station is a first application station configured to enhance and/or repair a seed layer of the microelectronic workpiece, and wherein at least one of the processing stations includes a material removal station, further wherein at least another of the processing stations includes a second application station configured to apply a

blanket layer of conductive material to the microelectronic workpiece, still further wherein at least another of the processing stations includes a thermal processing station configured to anneal a conductive material of the microelectronic workpiece.

[c20] 20. The apparatus of claim 1 wherein the application station is configured to electrophoretically deposit an electrophoretic resist material on the microelectronic workpiece, and wherein at least one of the processing stations includes a thermal processing station having a heater and being configured to receive the microelectronic workpiece with the electrophoretic resist material and elevate a temperature of the electrophoretic resist material, and wherein at least another of the processing stations includes a spray station having a spray vessel configured to carry a spray fluid, a spray support positioned proximate to the spray vessel and configured to carry the microelectronic workpiece, and a spray fluid manifold positioned within the spray vessel, the spray fluid manifold being coupleable to a source of spray fluid, the spray fluid manifold having a plurality of fluid jets directed toward the support to spray the microelectronic workpiece with the spray fluid.

[c21] 21. An apparatus for processing microelectronic workpieces, comprising:

a plurality of processing stations, all of the processing stations of the apparatus being manually accessible to a user to manually load microelectronic workpieces for processing, at least one of the processing stations including a material removal station configured to remove material from the microelectronic workpieces;

an input/output station configured to support at least one microelectronic workpiece for automatic transfer to and from the processing stations; and

a transfer device positioned proximate to the input/output station and the processing stations, the transfer device being automatically movable

to transfer microelectronic workpieces between the input/output station and the processing stations.

[c22] 22. The apparatus of claim 21 wherein the material removal station includes a rotor having a first portion and a second portion facing toward the first portion, the first and second portions defining a chamber volume configured to removably receive the microelectronic workpiece, wherein the first portion includes a first fluid passage having a first aperture directed into the chamber volume and facing the second portion, the first aperture being coupleable to a first fluid source, and wherein the second portion includes a second fluid passage having a second aperture directed into the chamber volume and facing the first portion, the second aperture being coupleable to a second fluid source.

[c23] 23. The apparatus of claim 21 wherein the material removal station includes:

a rotor having a first portion and a second portion facing toward the first portion, the first and second portions defining a chamber volume configured to removably receive the microelectronic workpiece, wherein the first portion includes a first fluid passage having a first aperture directed into the chamber volume and facing the second portion, and wherein the second portion includes a second fluid passage having a second aperture directed into the chamber volume and facing the first portion;

a first fluid source coupled to the first aperture to provide a first fluid to the first aperture; and

a second fluid source coupled to the second aperture to provide a second fluid to the second aperture, at least one of the first and second fluids being configured to remove material from the microelectronic workpiece.

[c24] 24. The apparatus of claim 21 wherein the material removal station includes:

a spray vessel configured to provide a spray fluid;

a support positioned proximate to the spray vessel, the support being configured to carry the microelectronic workpiece;

a spray fluid manifold positioned within the spray vessel, the spray fluid manifold being coupleable to a source of spray fluid, the spray fluid manifold having a plurality of fluid jets directed toward the support to spray the microelectronic workpiece with the spray fluid.

[c25] 25. The apparatus of claim 21 wherein the processing stations are arranged along a generally straight first line and wherein the transfer device includes a robot configured to move along a second line generally parallel to the first line, and wherein the apparatus further comprises an enclosure disposed around at least one of the processing stations, the enclosure having a first access aperture through which the user can manually access all the process stations, the enclosure having a second access aperture accessible to the robot and through which the robot can move microelectronic workpieces, with the second line being positioned between the first line and the first and second access apertures.

[c26] 26. The apparatus at claim 21 wherein the material removal station includes a vessel and a support movably positioned proximate to the vessel and configured to carry the microelectronic workpiece, the support being moveable between a first transferring position and a second transferring position spaced apart from the first transferring position, wherein the support is oriented to receive the microelectronic workpiece from the transfer device when the support is in the first transferring position, and wherein the support is oriented to receive the microelectronic workpiece manually from the user when the support is in the second transferring position, the support being configured to selectively stop its motion at the first and second transferring positions.

[c27] 27. The apparatus of claim 21, further comprising an enclosure having a first surface with a first access aperture and a second surface facing opposite from the first surface and having a second access aperture, the first and second access apertures alone being sized and positioned to allow manual access to the transfer device and all the processing stations carried by the chassis for loading the microelectronic workpieces and/or servicing an interior region of the enclosure.

[c28] 28. An apparatus for processing microelectronic workpieces, comprising:

a plurality of processing stations, all of the processing stations of the apparatus being manually accessible to a user to manually load microelectronic workpieces for processing, at least one of the processing stations including a thermal processing station having a thermal processing space configured to removably receive the microelectronic workpiece, the thermal processing station further including a heat transfer unit at least proximate to the thermal processing space to elevate a temperature of the microelectronic workpiece;

an input/output station configured to support at least one microelectronic workpiece for automatic transfer to and from the processing stations; and

a transfer device positioned proximate to the input/output station and the processing stations, the transfer device being automatically movable to transfer microelectronic workpieces between the input/output station and the processing stations.

[c29] 29. The apparatus of claim 28 wherein the thermal processing station includes an annealing station, the annealing station including:

a base;

a support carried by the base and configured to removably contact the microelectronic workpiece;

a lid proximate to the base, at least one of the base and the lid being movable relative to the other between a closed position and an open position, the lid and the base defining the thermal processing space when in the closed position;

a heater positioned between the base and the lid;

a first heat sink positioned proximate to the heater and movable relative to the heater between a first position with the first heat sink in thermal contact with the heater and a second position with the first heat sink spaced apart from the heater; and

a second heat sink positioned proximate to the first heat sink, the second heat sink being in thermal contact with the first heat sink when the first heat sink is in the second position.

[c30] 30. The apparatus of claim 28 wherein the thermal processing station includes:

a workpiece support configured to carry the microelectronic workpiece; and

a heat source positioned at least proximate to the workpiece support to transfer heat to the microelectronic workpiece.

[c31] 31. The apparatus of claim 28 wherein the processing stations are arranged along a generally straight first line and wherein the transfer device includes a robot configured to move along a second line generally parallel to the first line, and wherein the apparatus further comprises an enclosure disposed around at least one of the processing stations, the enclosure having a first access aperture through which the user can manually access all the process stations, the enclosure having a second access aperture accessible to the robot and through which the robot can move microelectronic workpieces, with the second line being positioned between the first line and the first and second access apertures.

[c32] 32. The apparatus of claim 28, further comprising an enclosure having a first surface with a first access aperture and a second surface facing opposite from the first surface and having a second access aperture, the first and second access apertures alone being sized and positioned to allow manual access to the transfer device and all the processing stations for loading the microelectronic workpieces and/or servicing an interior region of the enclosure.

[c33] 33. A method for processing microelectronic workpieces, comprising:

directing an automatic transfer device of a processing tool to move at least one first microelectronic workpiece to, from or both to and from a material application station of the tool, the material application station being one of a plurality of processing stations of the tool;

directing application of material to the at least one first microelectronic workpiece in the material application station; and

for each of the processing stations of the tool, manually loading a second microelectronic workpiece into the processing station and directing processing of each of the manually loaded second microelectronic workpieces in the processing stations, wherein directing processing of the second microelectronic workpieces in the material application station includes directing the application of material to the second microelectronic workpieces.

[c34] 34. The method of claim 33 wherein directing the application of material to the first and second microelectronic workpieces includes directing the application of a metal in an electrolytic process.

[c35] 35. The method of claim 33 wherein directing the application of material to the first and second microelectronic workpieces includes directing the application of an at least partially insulative material in an electrophoretic process.

[c36] 36. The method of claim 33 wherein directing the application of material to the first and second microelectronic workpieces includes directing the application of a photoresist material in an electrophoretic process, and wherein the method further comprises:

elevating a temperature of the photoresist material; and

rinsing the microelectronic workpiece.

[c37] 37. The method of claim 33 wherein directing the application of material to the first and second microelectronic workpieces includes directing the application of a solder material in an electrolytic process.

[c38] 38. The method of claim 33 wherein at least one of the processing stations includes a spray station configured to rinse the microelectronic workpieces, and wherein the method further comprises rinsing the first and second micorelectronic workpieces in the spray station.

[c39] 39. The method of claim 33 wherein the first and second microelectronic workpieces each include a seed layer and wherein directing the application of material to the first and second microelectronic workpieces includes enhancing, repairing or both enhancing and repairing the seed layer.

[c40] 40. The method of claim 33 wherein the first and second microelectronic workpieces include a seed layer and wherein directing the application of material to the first and second microelectronic workpieces includes disposing a blanket layer on the seed layer.

[c41] 41. The method of claim 33 wherein at least one of the processing stations includes a material removal station and wherein the method further comprises removing material from the first and second microelectronic workpieces in the material removal station.

[c42] 42. The method of claim 33 wherein at least one of the processing stations includes a thermal processing station and wherein the method further comprises elevating a temperature of the first and second microelectronic workpieces in the thermal processing station.

[c43] 43. The method of claim 33 wherein directing the application of material to the first and second microelectronic workpieces includes directing the application of solder to the first and second microelectronic workpieces, and wherein at least one of the processing stations includes a spray station, further wherein the method further comprises:

directing the automatic transfer device to load the first microelectronic workpiece into the spray station to rinse the first microelectronic workpiece after applying the solder to the first microelectronic workpiece; and

manually loading the second microelectronic workpieces into the spray station to rinse the second microelectronic workpieces after applying the solder to the second microelectronic workpieces.

[c44] 44. The method of claim 33 wherein directing the application of material to the first and second microelectronic workpieces includes directing the application of enhancement material to the first and second microelectronic workpieces, and wherein at least one of the processing stations includes a material removal station, another of the processing stations includes a multi-anode material application station, and yet another of the processing stations includes a thermal processing station, further wherein the method further comprises:

directing the automatic transfer device to load the first microelectronic workpiece into the material removal station to remove material from the first microelectronic workpiece, into the multi-anode material application station to apply a first conductive material to the first

microelectronic workpiece, and into the thermal processing station to anneal the first conductive material; and

manually loading the second microelectronic workpieces into the material removal station to remove material from the second microelectronic workpieces, manually loading the second microelectronic workpieces into the multi-anode material application station to apply a second conductive material to the second microelectronic workpieces, and manually loading the second microelectronic workpieces into the thermal processing station to anneal the second conductive material.

[c45] 45. The method of claim 33 wherein directing the application of material to the first and second microelectronic workpieces includes directing the application of electrophoretic resist material to the first and second microelectronic workpieces, and wherein at least one of the processing stations includes a thermal processing station, and another of the processing stations includes a spray station, further wherein the method further comprises:

directing the automatic transfer device to load the first microelectronic workpiece into the thermal processing station to elevate the temperature of the electrophoretic resist material on the first microelectronic workpiece, then into the spray station to rinse the first microelectronic workpiece; and

manually loading the second microelectronic workpieces into the thermal processing station to elevate the temperature of the electrophoretic resist material on the second microelectronic workpieces, then manually loading the microelectronic workpieces into the spray station to rinse the second microelectronic workpieces.

[c46] 46. The method of claim 33 wherein manually loading the second microelectronic workpieces includes manually loading the second microelectronic

workpieces while the automatic transfer device carries the at least one first microelectronic workpiece.

[c47] 47. The method of claim 33 wherein directing an automatic transfer device includes directing the automatic transfer device to move the at least one first microelectronic workpiece to, from or both to and from a support of the material application station while the support is in a first transferring position and wherein manually loading a second microelectronic workpiece includes manually transferring the second microelectronic workpiece to the support of the material application station while the support is in a second transferring position spaced apart from the first transferring position.

[c48] 48. The method of claim 33 wherein manually loading the second microelectronic workpieces includes releasably attaching the second microelectronic workpieces to a wand and moving the wand at least proximate to a support of the material application station.

[c49] 49. The method of claim 33 wherein manually loading the second microelectronic workpieces includes passing the second microelectronic workpieces over a shield positioned proximate to the automatic transfer device, with the shield at least restricting access to the automatic transfer device.

[c50] 50. A method for processing microelectronic workpieces, comprising:

directing an automatic transfer device of a processing tool to move at least one first microelectronic workpiece to, from or both to and from a material removal station of the tool, the material removal station being one of a plurality of processing stations of the tool;

directing removal of material from the at least one first microelectronic workpiece in the material removal station; and

for each of the processing stations of the tool, manually loading a second microelectronic workpiece into the processing station and directing processing of each of the manually loaded second microelectronic workpieces in the processing stations, wherein directing processing of the second microelectronic workpieces in the material removal station includes directing the removal material from the second microelectronic workpieces.

[c51] 51. The method of claim 50 wherein removing material from the first and second microelectronic workpieces includes directing a first fluid toward a first surface of the microelectronic workpieces and directing a second fluid different than the first fluid toward a second surface of the microelectronic workpieces, with the second surface of the microelectronic workpiece facing opposite from the first surface.

[c52] 52. The method of claim 50 wherein removing material from the first and second microelectronic workpieces includes bevel etching a peripheral region of the first and second microelectronic workpieces.

[c53] 53. The method of claim 50 wherein removing material from the first and second microelectronic workpieces includes directing a spray of fluid through a plurality of spray nozzles and toward the first and second microelectronic workpieces.

[c54] 54. A method for processing microelectronic workpieces, comprising:

directing an automatic transfer device of a processing tool to move at least one first microelectronic workpiece to, from or both to and from a thermal processing station of the tool, the thermal processing station being one of a plurality of processing stations of the tool;

directing thermal processing of the at least one first microelectronic workpiece in the thermal processing station; and

for each of the processing stations of the tool, manually loading a second microelectronic workpiece into the processing station and directing processing of each of the manually loaded second microelectronic workpieces in the processing stations, wherein directing thermal processing of the second microelectronic workpieces in the thermal processing station includes directing the application of heat to the second microelectronic workpieces.

[c55] 55. The method of claim 54 wherein directing thermal processing of the first and second microelectronic workpieces includes annealing a conductive material applied to the first and second microelectronic workpieces.

[c56] 56. The method of claim 54 wherein directing thermal processing of the first and second microelectronic workpieces includes, for each microelectronic workpiece:

bringing each microelectronic workpiece into thermal contact with a heater;

bringing a first heat sink into thermal contact with the heater to cool the heater and each microelectronic workpiece; and

bringing a second heat sink into thermal contact with the first heat sink to cool the first heat sink.